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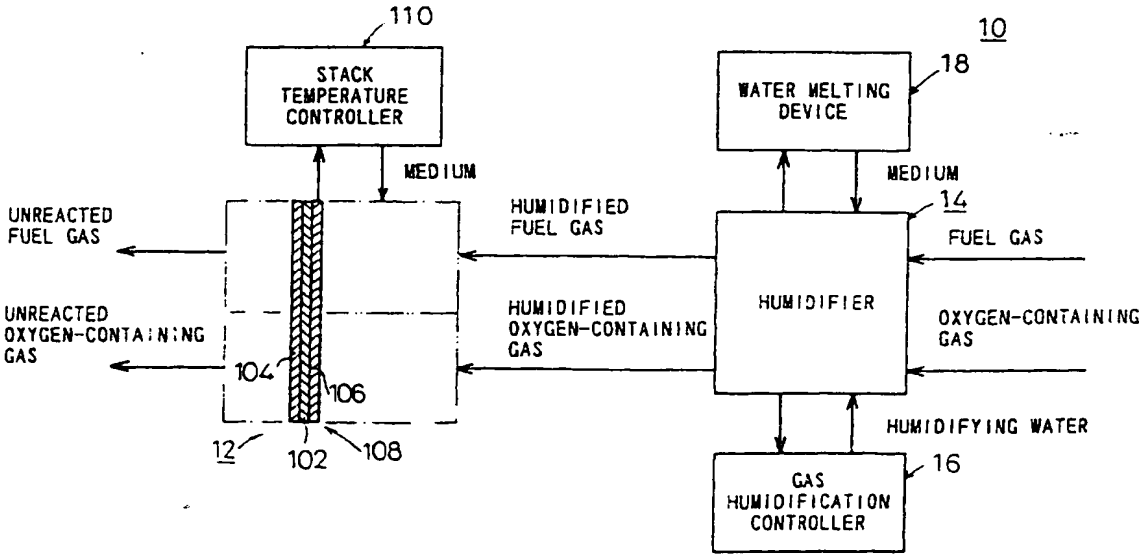
(54) Gas humidifying device for use with a fuel cell

(57) A gas humidifying device (10) for use with a fuel cell (12) in which water permeable membranes (22a-22f) are provided with fuel gas passages (34a-34c) and oxygen-containing gas passages (48a-48c) formed on one side of the water permeable membranes, and wherein humidifying water passages (40a-40f, 144) are formed on the other side thereof. Medium supply passages (44, 150) are provided independently from, yet in proximity to the water passages, for supplying a medium having a melting point lower than that of water. Accordingly, a melting operation for melting the water in the interior of the humidifier (14) can be easily and swiftly carried out, while the device remains simple in structure.

FIG. 1



EP 0 831 543 A1

which are supplied to the humidifier 14, and a water melting device 18 for melting water which has become frozen in the interior of the humidifier 14

In the humidifier 14, a first fuel gas supply plate 20, a first water permeable membrane (water permeable element) 22a, supply plates 24a, 24b for water and the medium, a second water permeable member 22b, a third supply plate 26 for the fuel gas and the oxygen containing gas, a third water permeable membrane 22c, further second supply plates 24a, 24b, a fourth water permeable membrane 22d, a further third supply plate 26, a fifth water permeable membrane 22e, further second supply plates 24a, 24b, a sixth water permeable membrane 22f, and a fourth supply plate 28 for the oxygen-containing gas are integrally arranged along the direction of the Arrow X shown in FIGS. 2 and 3.

The first supply plate 20 is flat on one surface thereof, and on the other side are disposed a plurality of projections 30 which extend in a horizontal direction, wherein due to this structure, perpendicularly directed serpentine fuel gas passages 34a are formed along one side surface 32a of the first water permeable membrane 22a.

On the second supply plates 24a, 24b, on respective side surfaces thereof, a plurality of projections 36a, 36b are disposed which extend horizontally therealong, wherein due to this structure, on the other side surface 32b of the first water permeable membrane 22a, and on one side surface 38a of the second water permeable membrane 22b, perpendicularly directed serpentine humidifying water passages 40a, 40b are formed. On surfaces of the second supply plates 24a, 24b which mutually face each other, a plurality of relatively short length projections 42a, 42b are formed extending horizontally therealong, wherein both of such projections 42a, 42b abut each other, thereby forming a medium flow passage 44.

As shown in FIG. 2, the third supply plate 26 has a plurality of projections 46a, 46b which extend horizontally along both surfaces thereof. An oxygen-containing gas passage 48a is formed between the projections 46a and the other side surface 38b of the second water permeable membrane 22b. Similarly, a fuel gas passage 34b is formed between the projections 46b and one side surface 50a of the water permeable membrane 22c. A water passage 40c is formed between the third water permeable membrane 22c and the other side surface 50b of the second supply plate 24a.

Between the surface 52a of the fourth water permeable membrane 22d and the second supply plate 24b, as well as between the surface 52b of the fourth water permeable membrane 22d and the third supply plate 26, a water passage 40d and an oxygen containing gas passage 48b are formed. Both side surfaces 54a, 54b of the fifth water permeable membrane make up parts of a fuel gas passage 34c and a water passage 40e, and both side surfaces 56a, 56b of the sixth water permeable membrane 22f make up parts of respective water passages 40f and an oxygen containing gas passage 48c.

In the humidifier 14, there are disposed a fuel gas introduction port 60 for introducing a fuel gas into the fuel gas passages 34a - 34c, an oxygen containing gas introduction port 62 for introducing an oxygen containing gas into the oxygen containing gas passages 48a - 48c, a water introduction port 64 for introducing humidifying water into the water passages 40a - 40f, a medium introduction port 66 for introducing a medium into the medium passage 44, a fuel gas discharge port 68 for discharging and conveying a post-humidified fuel gas to the fuel cell 12, an oxygen containing gas discharge port for discharging and conveying a post-humidified oxygen containing gas to the fuel cell 12, a water discharge port 72 for discharging any unused water, and a medium discharge port 74 for discharging the medium after the melting processing has been performed.

As shown in FIG. 4, a first circulatory route 80 is provided in the gas humidifying controller 16, intercommunicating the water introduction port 64 and the water discharge port 72, and circulating water inside the humidifier 14. The first circulatory route 80 includes therein a water tank 84, wherein the water tank 84 and the humidifier 14 are brought into communication via a first circulatory path 86. In the first circulatory path 86, a water circulation pump 88 for supplying water from the water tank 84 to the humidifier 14, a pressure meter 90 for detecting water pressure, and a flow rate meter 92 for detecting a water flow rate are also arranged. The pressure meter 90 and/or the flow rate meter 92 make up a freezing detection means for detecting a frozen state of the water.

The water melting device 18 is made up of a second circulatory route 82, providing communication between the medium introduction port 66 and the medium discharge port 74, for circulating a medium to the inside of the humidifier 14. The second circulatory route is provided with a reserve tank 94, wherein the reserve tank 94, the medium introduction port 66 of the humidifier 14, and the medium discharge port 74 are maintained in communication through a second circulatory path 96. In the second circulatory path 96, there are also arranged a medium circulation pump 98 for supplying the medium from the reserve tank 94 to the humidifier 14, and a heat-exchange device (heating means) 100 for conveying heat to the medium for melting the water, when it is detected that the water is in a frozen state.

As for the medium, in particular, any of the following may be used, wherein the respective melting temperatures, under ordinary pressure are shown in parenthesis: methanol (-97.78°C), ethanol (-114.5°C), propanol (-127°C), isopropanol (-89.5°C), 1-butanol (-89.53 °C), 2-methyl-1-propanol (-108°C), 2-butanol (-114.7°C), 1-hexanol (-44.6°C), 1-octanol (-14.9°C), 2-ethyl-hexanol (-76°C), methane (-182.48°C), ethane (-183.6°C), propane (-187.69°C), ethylene-glycol (-12.6°C), propylene-glycol (-60 °C), ethyl-ether (-116.3°C), toluene (-95°C), ammonia (-77.7°C), methylamine (-93.46°C),

14, a gas humidity controller 16 and a temperature management controller 122 for melting frozen water inside the humidifier 14, each of which are interconnected to the fuel cell 12. The temperature management controller 122 is equipped with a first circulatory path 124 by which a medium is supplied to a cooling passage (not shown) in the interior of the fuel cell 12, a second circulatory path 126 by which the medium is circulated through the interior of the humidifier 14, and a switching valve means 128 for both establishing and blocking communication between the first and second circulatory paths 124 and 126.

A medium reserve tank 130, a medium circulating pump 132 and a temperature control device 134, such as a heat exchange device, for adjusting the temperature of the medium are respectively arranged in the first circulatory path 124. The switching valve means 128 is made up of first and second switching valves 136a and 136b arranged respectively in the first circulatory path 124, wherein the second circulatory path 126 is likewise connected to the first and second switching valves 136a and 136b.

With the humidifying device constructed in this manner, humidification of the fuel and oxygen-containing gases is conducted in the humidifier 14 by way of the gas humidity controller 16, and the fuel and oxygen-containing gases which have been humidified are then supplied to the fuel cell 12. In the temperature management controller 122, the medium contained in the reserve tank 130 is supplied, under operation of the pump 132, along the first circulatory path 124 in the direction of the arrows A, and is circulated through non-illustrated cooling passages inside the fuel cell 12.

On the other hand, when a frozen state of the water in the humidifier is generated, the second circulatory path 126 is brought into communication with the first circulatory path 124 by the switching valves 136a, 136b. As a result, the medium in the reserve tank 130 is supplied in the direction of the arrows B, so that first it is introduced into the humidifier 14, and after the frozen water inside the humidifier 14 has been melted, the medium is then supplied to the interior of the fuel cell.

Accordingly, the temperature management controller 122 possesses, in a single unit, the functions of the stack temperature controller 110 and the water melting device 18 of the first embodiment, wherein the structure of the humidifying device is further simplified.

In FIG. 6, the interior details of a humidifier 140 structured according to a third embodiment of the humidifying device of the present invention are shown in outline form. Further, features which are the same as found in the humidifier 14 of the humidifying device 10 according to the first embodiment are indicated using like reference numerals, and for the sake of brevity, detailed discussion thereof is omitted.

In the humidifier 140, in place of the two second supply plates 24a, 24b of the humidifier 14, a single second supply plate 142 is provided. On both surfaces of the second supply plate 142, plural projections 146 are disposed, forming perpendicularly directed serpentine humidifying passages 144. In a central portion of the second supply plate 142, parallel to the humidifying water passages 144, a pipe 148 is disposed, wherein a medium flow passage 150 is formed in the control body 148 enabling a low melting point medium to flow therethrough.

Accordingly, when using the humidifier 140, the same effects achieved by the humidifier 14 are attained.

As has been described above, with the humidifying device for use with a fuel cell according to the present invention, when water which is used for humidifying a fuel gas and oxygen-containing gas becomes frozen within the water passages, a medium having a melting point below that of water is supplied to medium flow passages which are disposed in the vicinity of the water passages, thereby instigating heat-exchange between the water and the medium. As a result, the fuel cell retains a simplified structure, together with enabling simple and efficient melting of the humidifying water.

Claims

1. A gas humidifying device (10) for a fuel cell (12), in which said humidifying device humidifies a fuel gas and/or an oxygen-containing gas which is supplied to the fuel cell, in which an anode electrode (106) and cathode electrode (104) oppositely face each other with a solid electrolyte membrane (102) interposed therebetween, comprising:

   a water permeable element (22a-22f);
   a gas supply passage (34a-34c, 48a-48c) formed on one side surface of said water permeable element (22a-22f);
   a humidifying water passage (40a-40f, 144) formed on the other side surface of said water permeable element; and
   a medium flow passage (44, 150) for supplying a medium having a melting point below that of water which is disposed independently from yet proximate to said humidifying water passage (40a-40f, 144).

2. The gas humidifying device according to claim 1, further comprising a circulatory route (82, 126) for circulating said medium to said medium passage, and a heating means (100, 134) disposed in said circulatory route for conveying heat to said medium for melting said water when it is detected that said water has become frozen.

3. The gas humidifying device according to claim 1 or 2, further comprising:

   a first circulatory path (124) for supplying said

FIG. 1

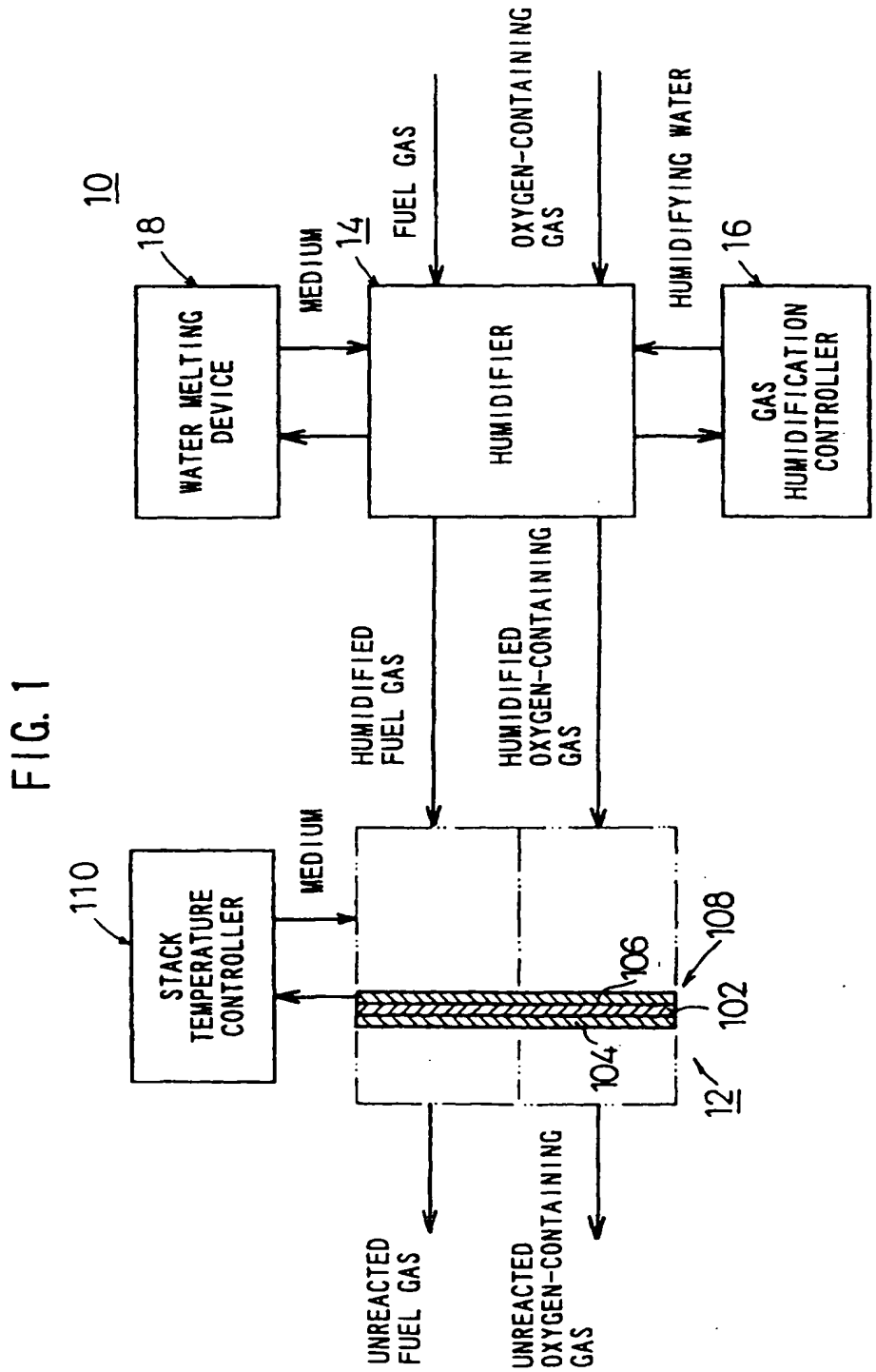
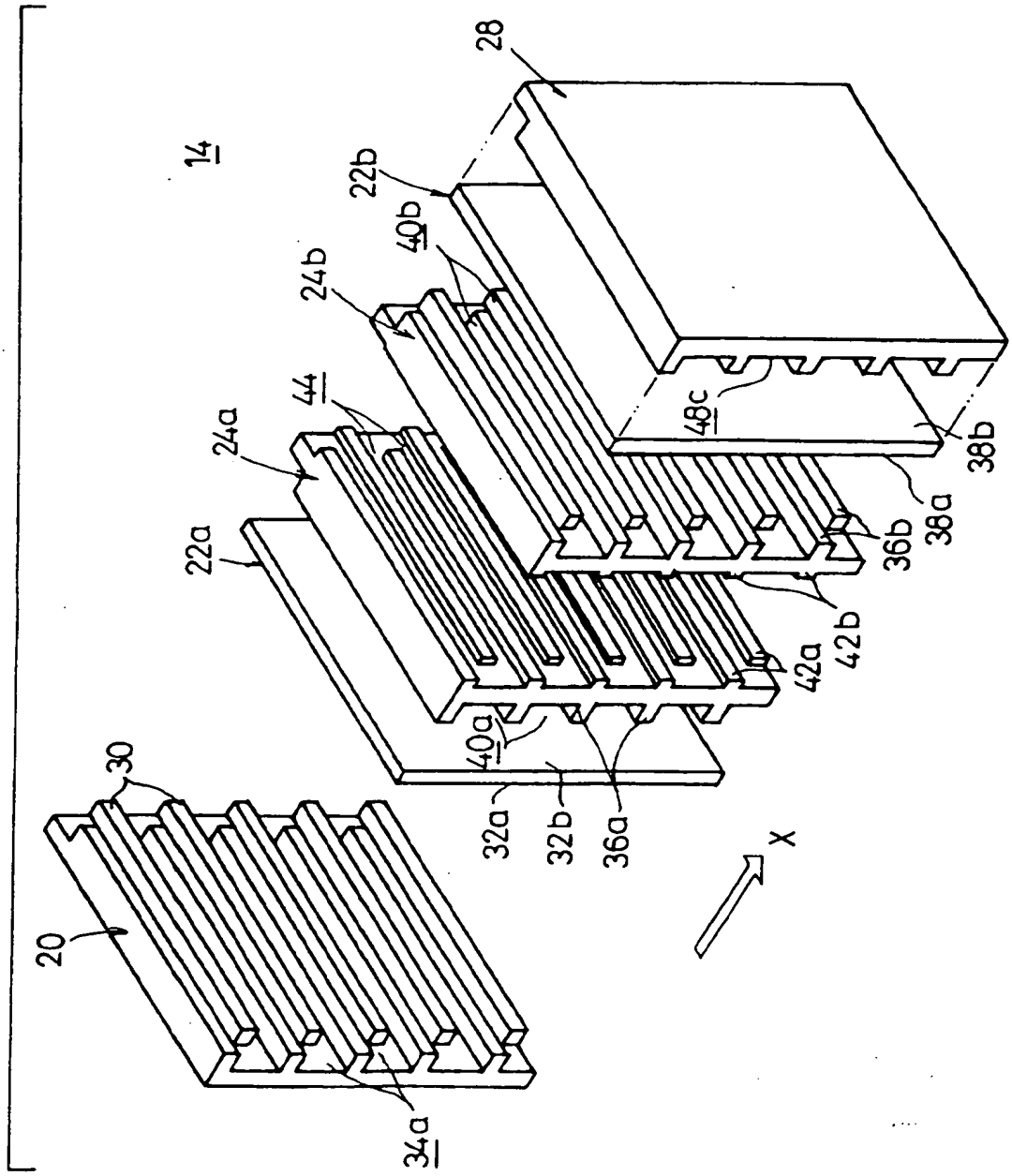


FIG. 3



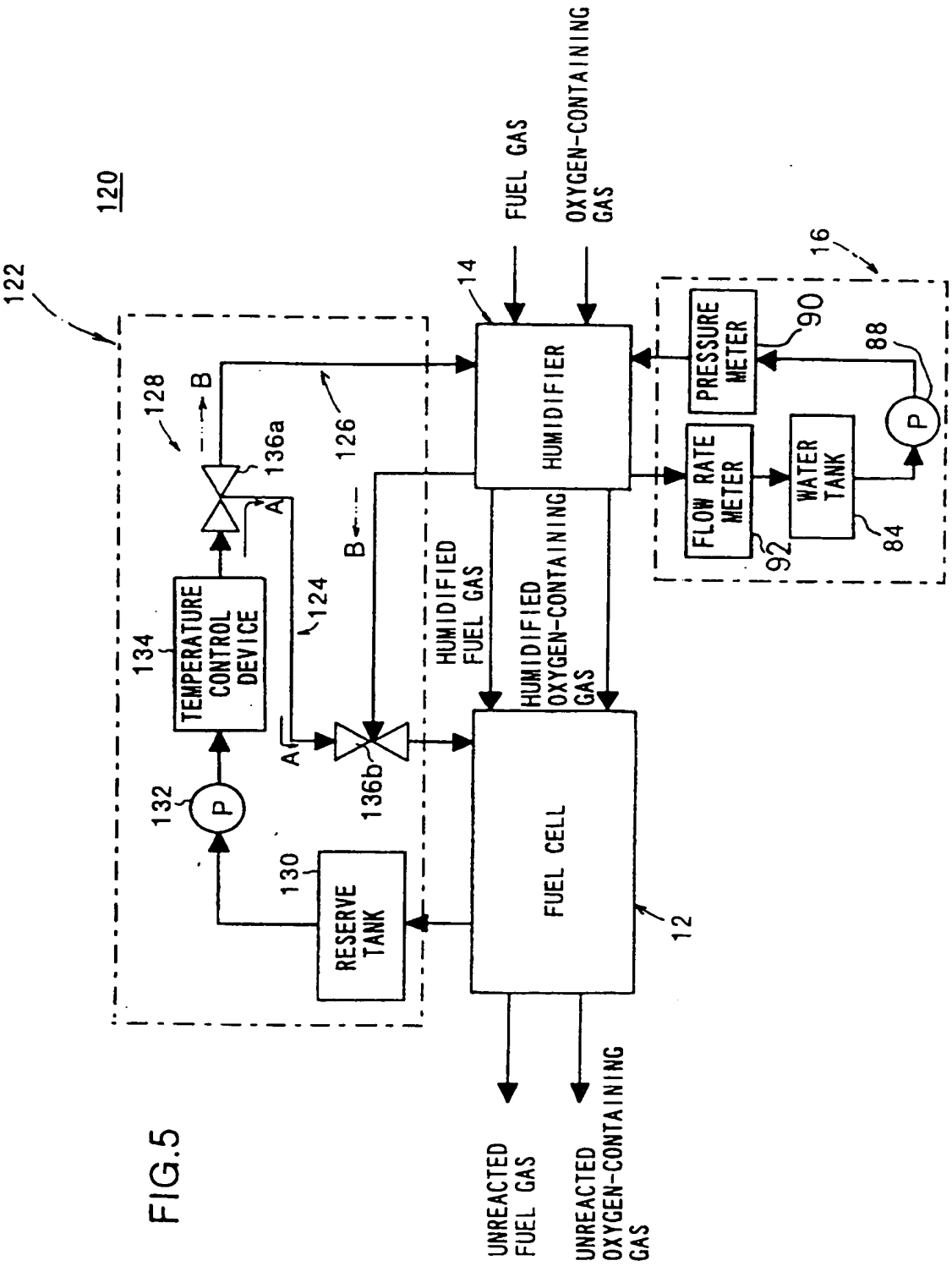


FIG.5

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EUROPEAN SEARCH REPORT

Application Number
EP 97 30 6797

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
Y	PATENT ABSTRACTS OF JAPAN vol. 096, no. 004, 30 April 1996 & JP 07 326376 A (MITSUBISHI HEAVY IND LTD), 12 December 1995, * abstract *	1-5	H01M8/04 H01M8/10
Y	PATENT ABSTRACTS OF JAPAN vol. 096, no. 007, 31 July 1996 & JP 08 064218 A (KANSAI ELECTRIC POWER CO INC:THE;FUJI ELECTRIC CO LTD), 8 March 1996, * abstract *	1-5	
Y	PATENT ABSTRACTS OF JAPAN vol. 095, no. 011, 26 December 1995 & JP 07 226222 A (MITSUBISHI HEAVY IND LTD), 22 August 1995, * abstract *	1-5	
Y	PATENT ABSTRACTS OF JAPAN vol. 018, no. 419 (E-1589), 5 August 1994 & JP 06 132038 A (FUJI ELECTRIC CO LTD), 13 May 1994, * abstract *	1-5	TECHNICAL FIELDS SEARCHED (Int.Cl.6) H01M
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Y	PATENT ABSTRACTS OF JAPAN vol. 095, no. 008, 29 September 1995 & JP 07 135012 A (TOYOTA MOTOR CORP), 23 May 1995, * abstract *	1-5	

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
MUNICH	12 January 1998	Engl, H

CATEGORY OF CITED DOCUMENTS

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